

Wave Rotor Research and Technology Development

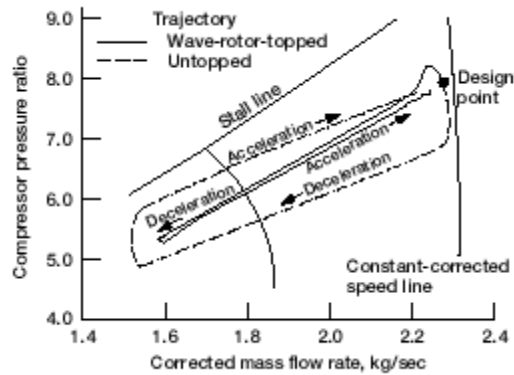
Wave rotor technology offers the potential to increase the performance of gas turbine engines significantly, within the constraints imposed by current material temperature limits. The wave rotor research at the NASA Lewis Research Center is a three-element effort:

1. Development of design and analysis tools to accurately predict the performance of wave rotor components
2. Experiments to characterize component performance
3. System integration studies to evaluate the effect of wave rotor topping on the gas turbine engine system

In the last year, significant progress was made in the dynamic simulation of wave rotors and gas turbine engines. The figure shows the response of wave-rotor-topped and baseline gas turbine engines to a step change in fuel flow: the wave-rotor-topped engine is more stable with respect to burner-induced surge (ref. 1).

Progress was also made in advanced component research:

1. Rotor passage flow area variation was found to improve aerodynamic performance (ref. 2).
2. A new gas dynamic wave cycle was developed that greatly alleviates the thermal loading of the wave rotor and its ducting (ref. 3).
3. Gas dynamic wave cycles and fuel/air premixing schemes were developed for wave rotors with combustion internal to the wave rotor (this approach conceptually eliminates the conventional burner of the gas turbine engine while still providing the engine-performance benefits afforded by wave rotor topping (ref. 4)).
4. A preliminary assessment of wave turbines (i.e., wave rotors that produce net shaft power) revealed that wave turbine topping potentially enhances engine specific power more than the classical pressure-exchanger (i.e., zero-net-shaft-power wave rotor) topping does (ref. 5)



Comparison of the dynamic responses of wave-rotor-topped and untopped gas turbine engines to step changes in fuel flow.

Progress has continued on the four-port pressure-exchanger experiment, which is designed to demonstrate startup, self-cooling effectiveness, and passive end-wall-leakage control, and to generate on- and off-design wave rotor performance data (i.e., a wave rotor map). The experiment uses an electric heater to add energy to the wave cycle in place of the burner component of the gas turbine engine. The experiment will operate at lower temperatures and pressures than would a wave rotor in an engine; however, all pressure and temperature ratios will be reproduced without the complications of variable gas properties (ref. 6).

A collaborative effort with the Allison Engine Company has yielded a preliminary design layout for a potential wave-rotor-enhanced demonstrator based on the Allison 250 turboshaft engine (ref. 7). Significant findings from this contracted effort include the following:

1. With existing Allison 250 engine turbomachinery hardware, wave rotor topping increases specific power by 20 percent and concomitantly decreases specific fuel consumption by 22 percent at full power.
2. Improvements in specific power are maintained at part-power operation.
3. The surge margin of the topped engine is equivalent to that of the production engine.
4. The wave rotor maintains high off-design performance.

References

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